

**Systematic Study
of
Particle Production
at High p_T
with the
PHENIX Experiment
at RHIC**

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PANIC – Santa Fe , Oct. 24 2005

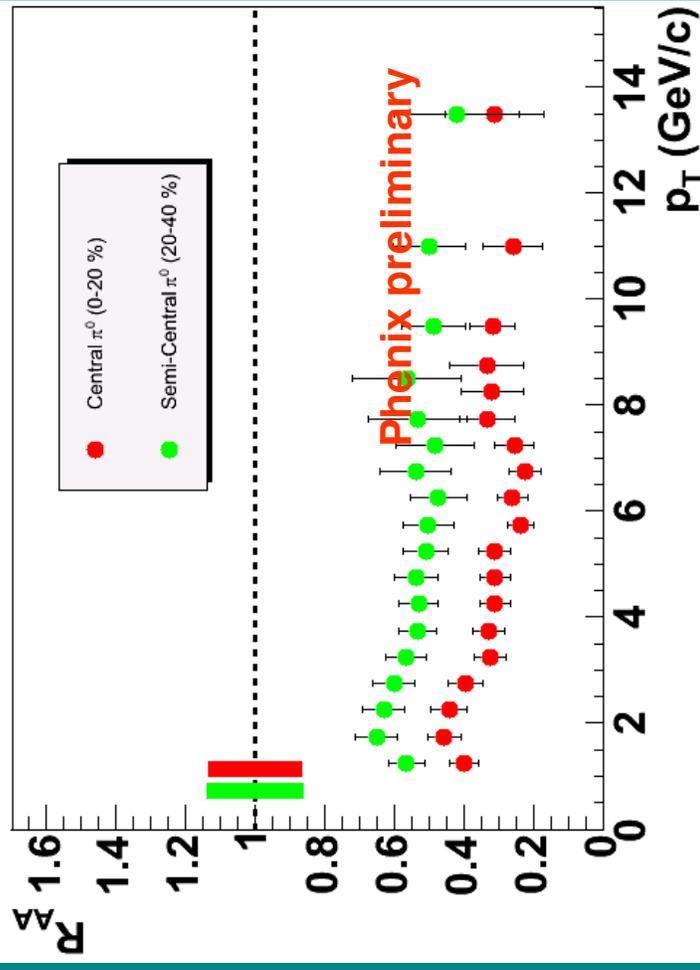
4 main discoveries of single particle production at high p_T in RHIC Run 1-3

1

Suppression of π^0 production in Au+Au relative to binary scaled p+p

$$R_{AB} = \frac{(1/N_{AB}^{\text{evt}}) d^2N_{AB}/dydp_T}{\langle T_{AB} \rangle d^2\sigma_{pp}/dydp_T}$$

$$\langle N_{coll} \rangle / \sigma_{NN}$$



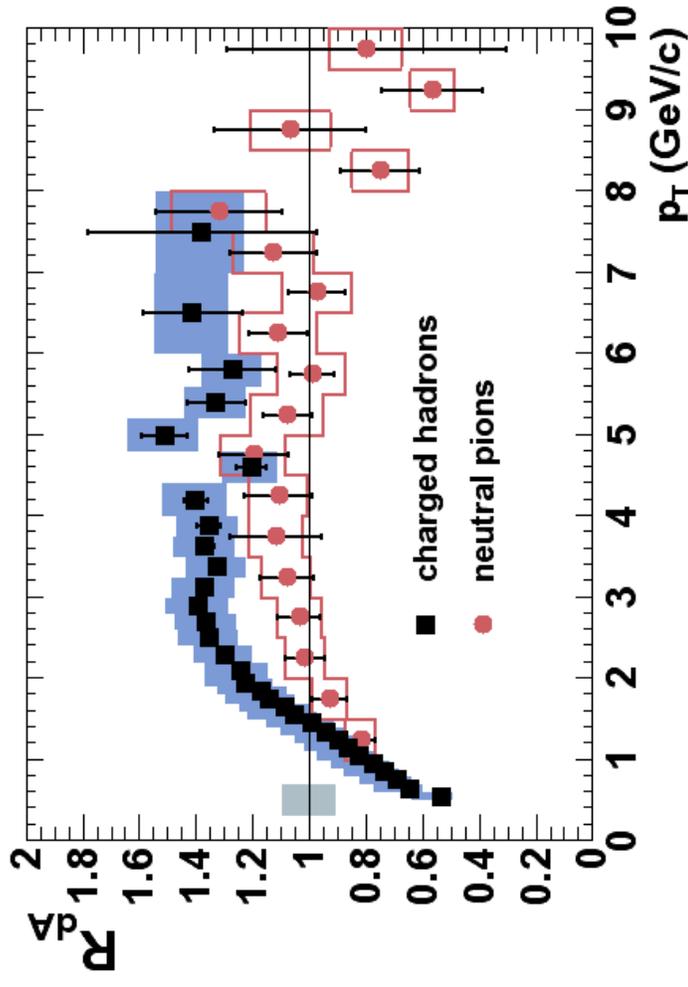
Phys. Rev. Lett. 91, 072301 (2003)

4 main discoveries of single particle production at high p_T in RHIC Run 1-3

2

No suppression in d+Au:
Suppression in Au+Au is a final state effect

- Initial-state effects ruled out as explanation for suppression in Au+Au at mid-rapidity



Phys. Rev. Lett. 91, 072303 (2003)

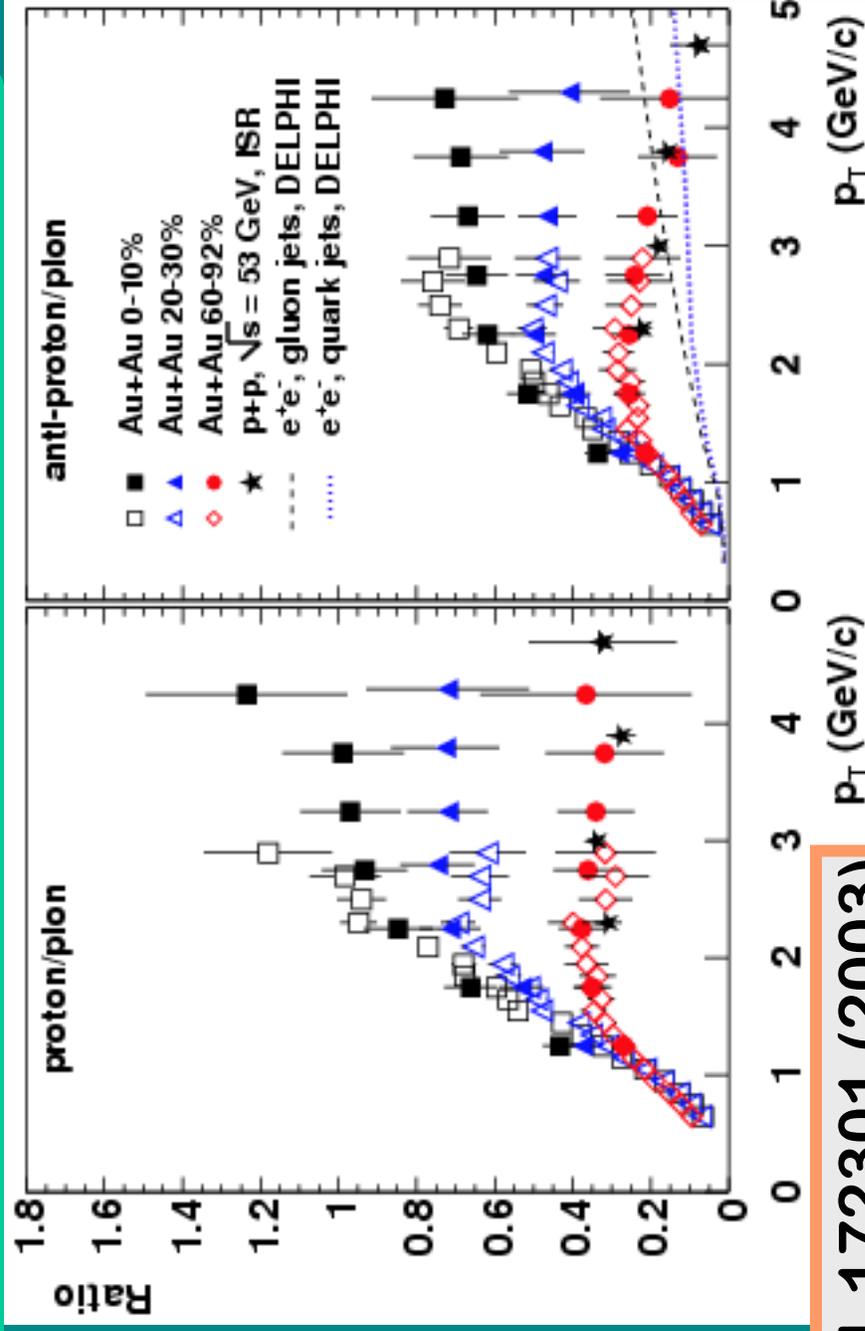
4 main discoveries of single particle production at high p_T in RHIC Run 1-3

3

Large proton to pion and anti-proton to pion ratio

Strong radial flow ?

Recombination ?



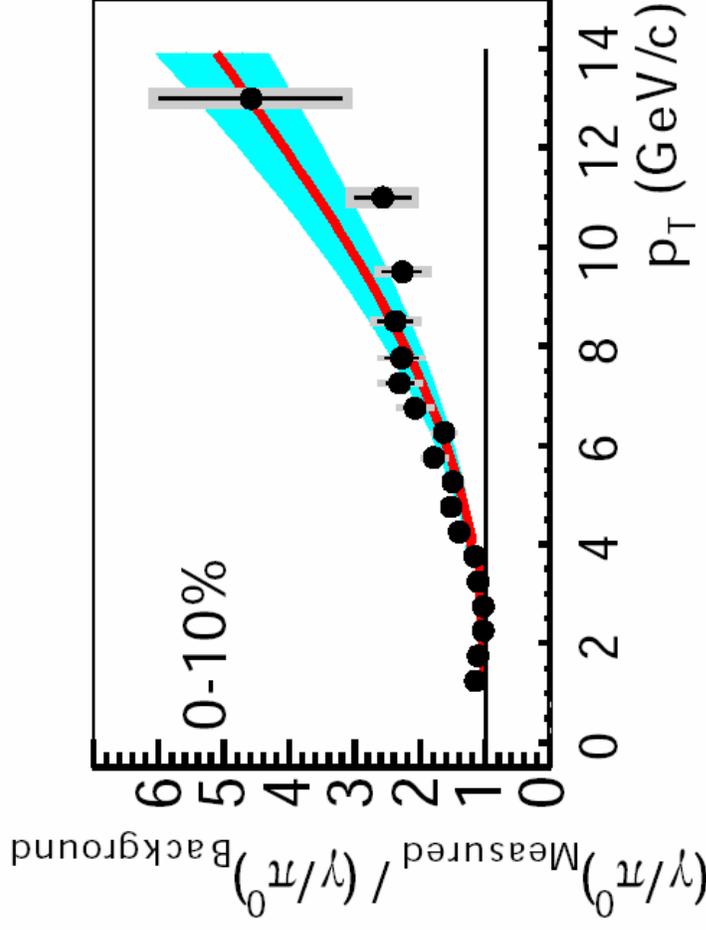
Phys. Rev. Lett. 91, 172301 (2003)

4 main discoveries of single particle production at high p_T in RHIC Run 1-3

4

Direct photons scale with N_{Coll}

- Important test of QCD and initial state
 - Photons don't interact strongly with medium
 - Pure N_{Coll} scaling relative to pQCD calculation



Phys. Rev. Lett. 94, 232301 (2005)

4 main discoveries of single particle production at high p_T in RHIC Run 1-3

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What's new ?

A huge collection of data

RHIC Run 01 - 05

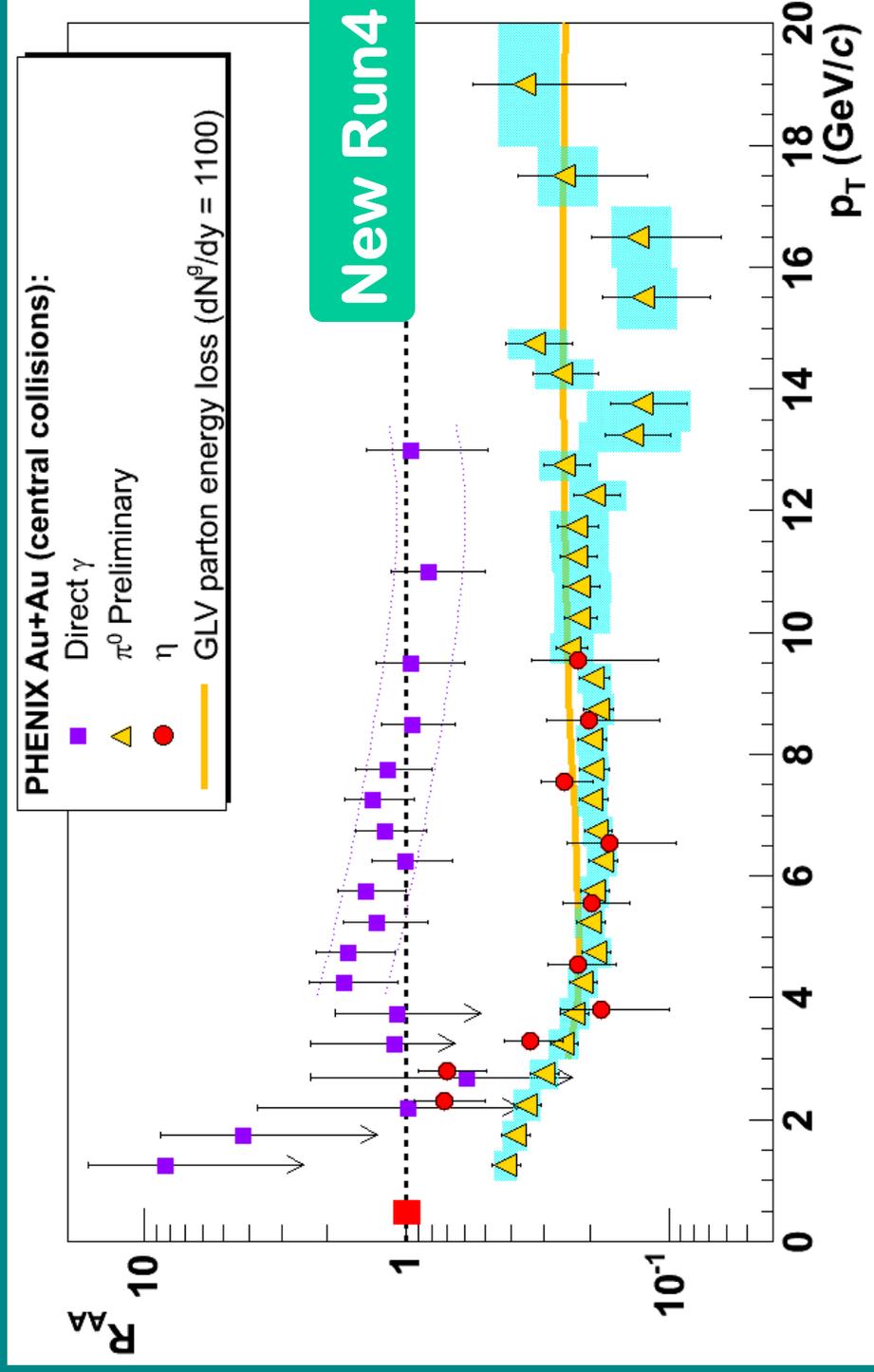
	p+p	d+Au	Au+Au	Cu+Cu
22.4 GeV				<input checked="" type="radio"/>
62.4 GeV	<input checked="" type="radio"/>		<input checked="" type="radio"/>	<input checked="" type="radio"/>
130 GeV			<input type="radio"/>	
200 GeV	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Reference		sQGP ?	Comp.

- Run 1 - 3
- Run 4 - 5
- Run 6 ?



particle suppression

R_{AA} in AuAu at 200 GeV

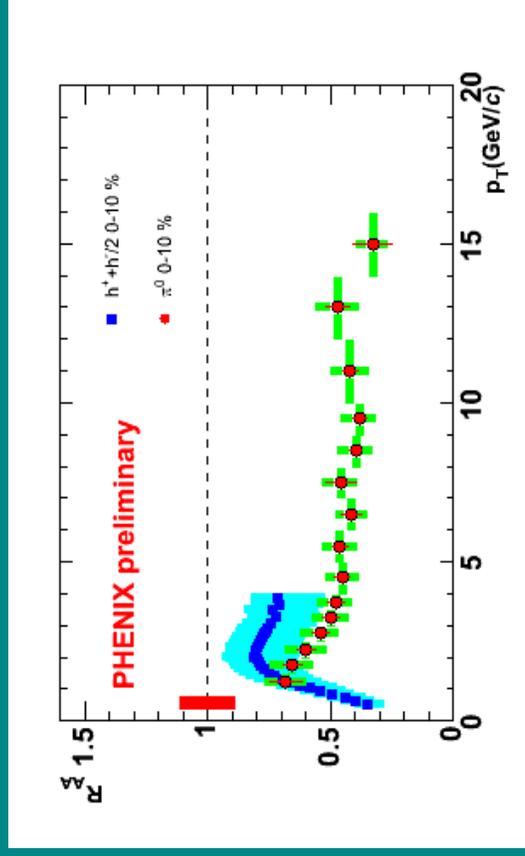
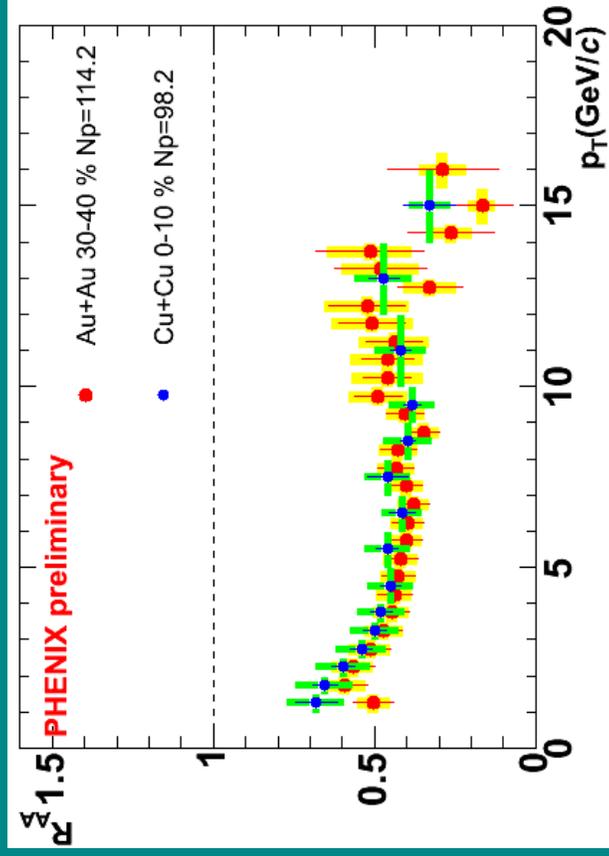


π^0 flat up to high p_T
Suppression of η similar to π^0

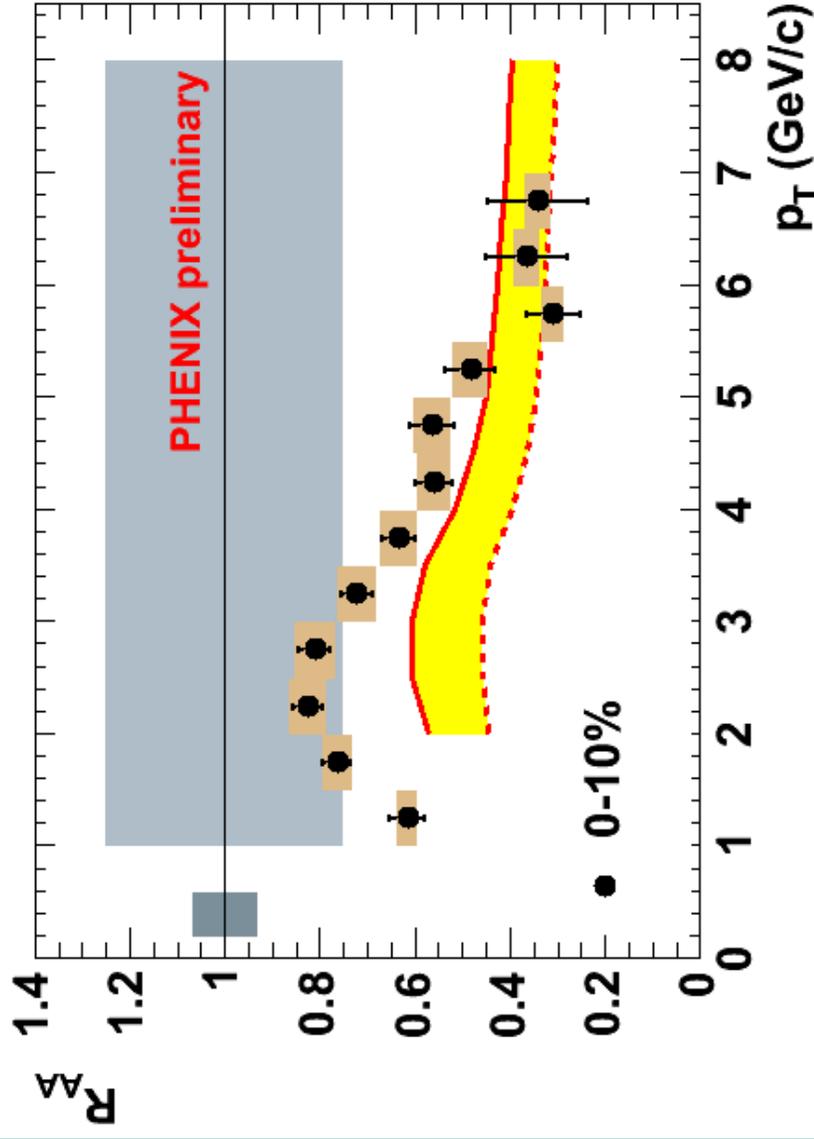
TadaAki Isobe, this session

Comparison Au+Au and Cu+Cu

- R_{AA} in Cu+Cu
- $R_{AA} \sim 0.4$ in central collisions
 - Strong energy loss even in light colliding system
 - Similar for same N_{part}
 - Charged particles not suppressed as strongly



R_{AA} for π^0 at 62.4 GeV



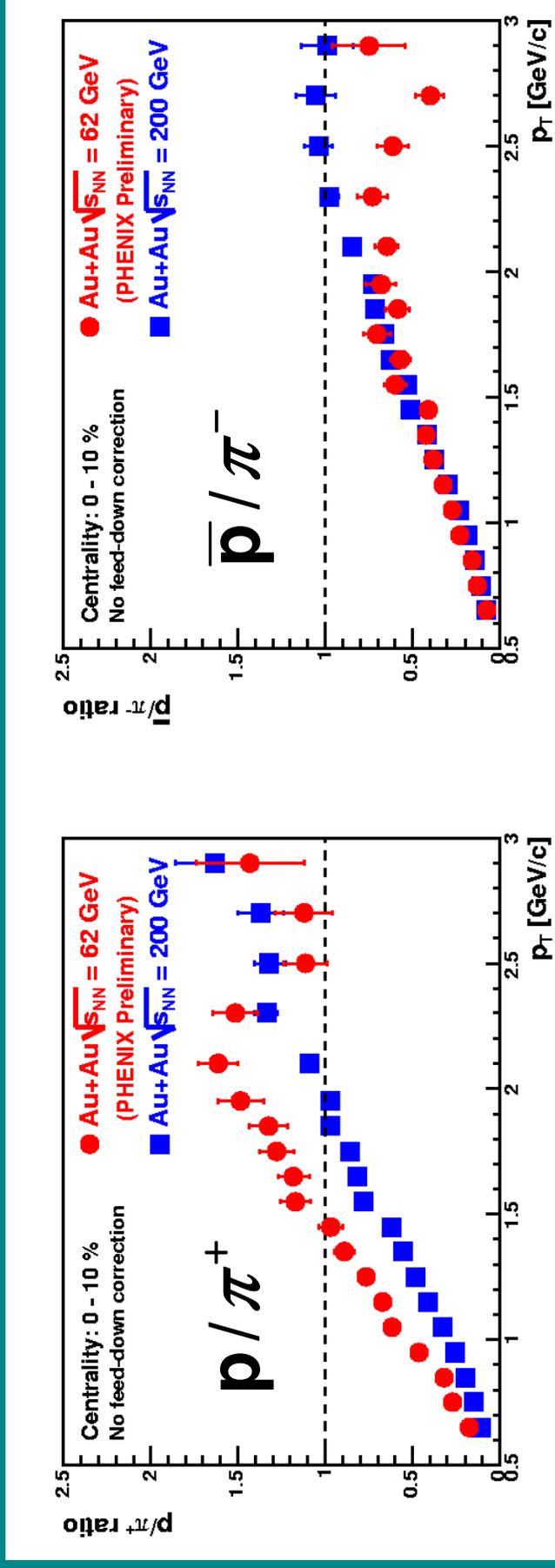
Vitev
nucl-th/0404052

- Same tendency as 200 GeV Au+Au
- Less suppression at intermediate p_T (compared to 200 GeV)
- Reasonably good agreement with theory within uncertainties
- Uncertainty in the p_T shape (esp. low p_T) of p+p reference ...



baryon anomaly

Energy dependence



- 62.4 GeV data:

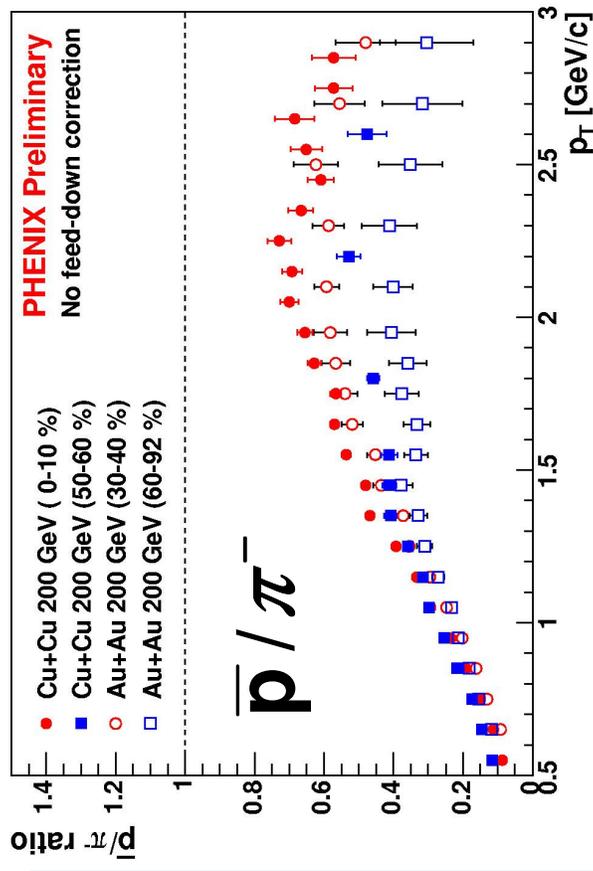
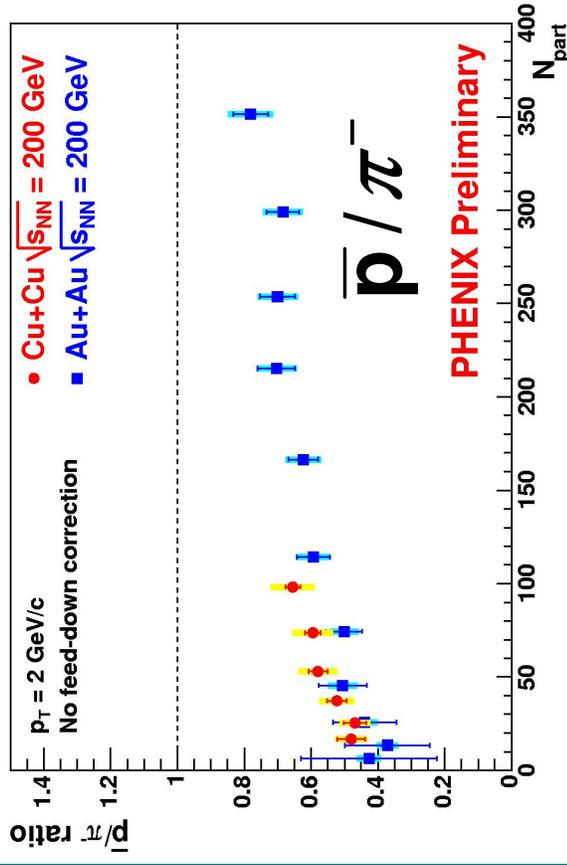
- Slightly larger proton contribution
- Slightly smaller anti-proton contribution
- Explanation by
 - Difference in slopes of spectra from fragmentation and recombination ?
 - Participant flow ?

System Size Dependence

At similar N_{part}
Particle ratios similar in
Cu+Cu and Au+Au

centrality dependence

p_T dependence

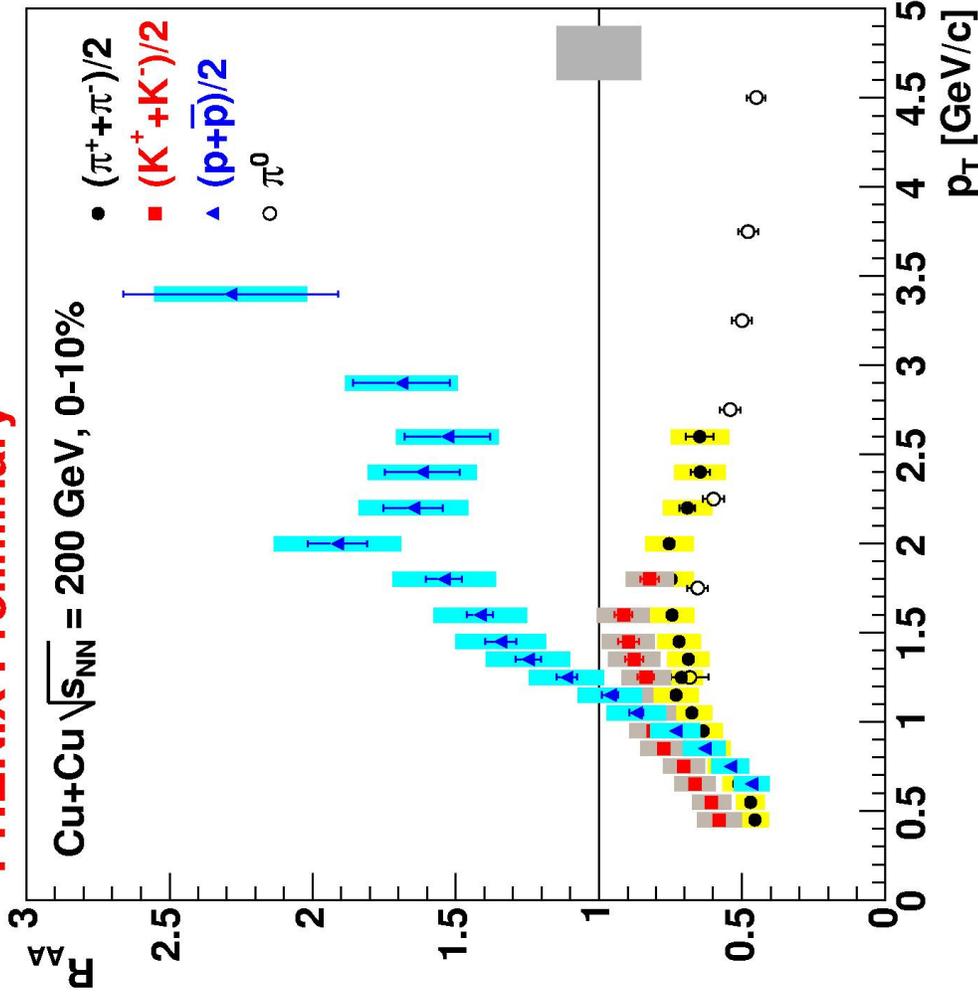


...also observed in p/π^+ and K/π

N_{part} scaling of ratios

R_{AA} in CuCu for different particles

PHENIX Preliminary



At similar N_{part} :

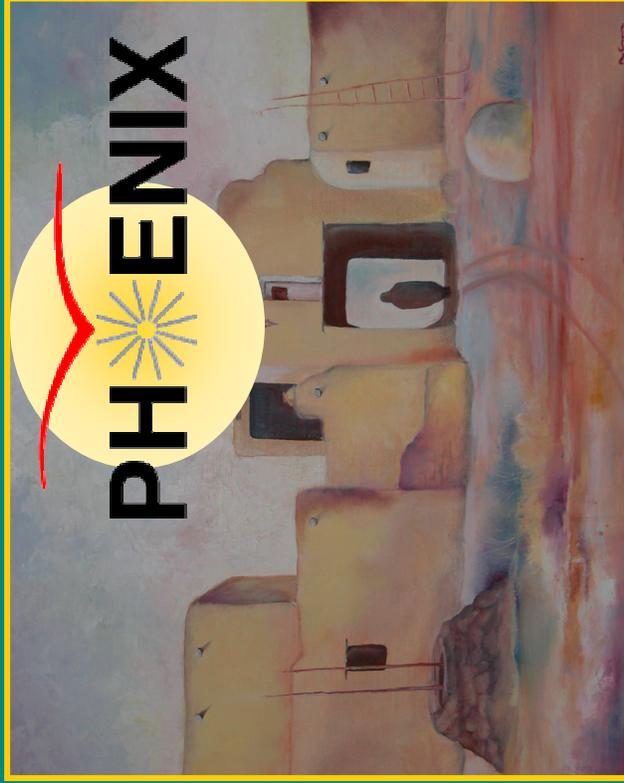
R_{AA} similar in
Cu+Cu and Au+Au

Magnitude of enhancement
or suppression

p_T dependence

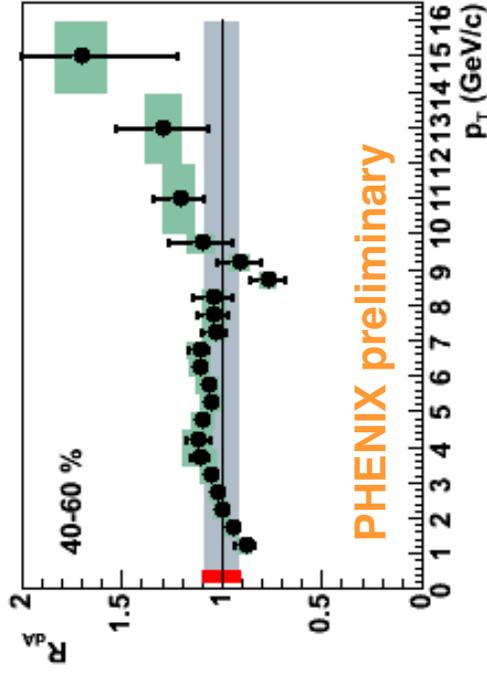
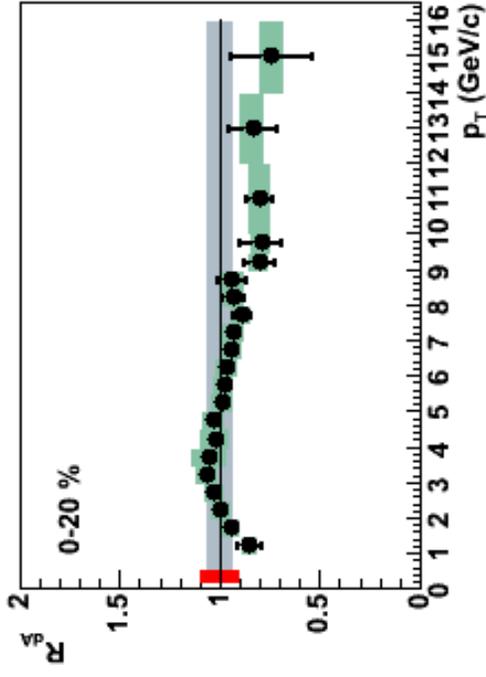
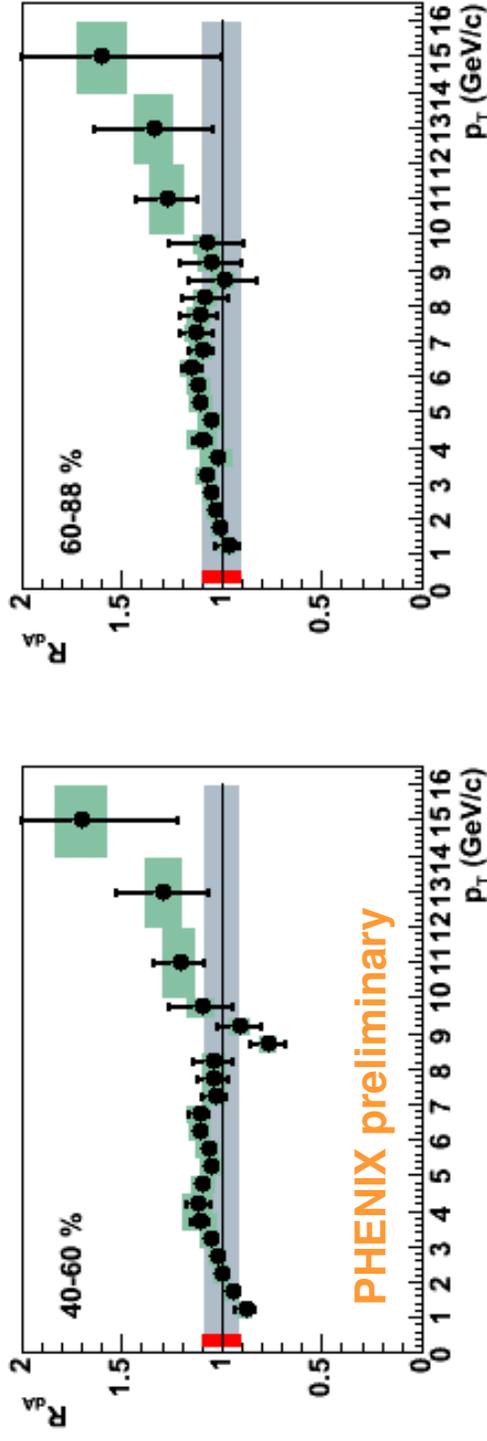
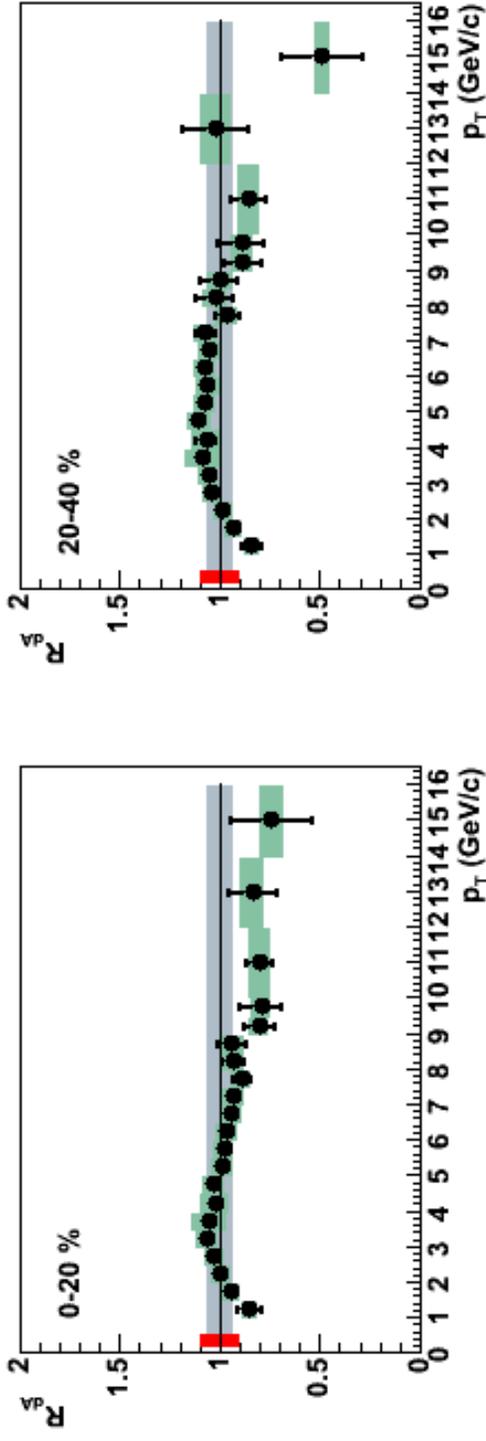
Particle species
dependence

↑ N_{part} scaling of R_{AA}



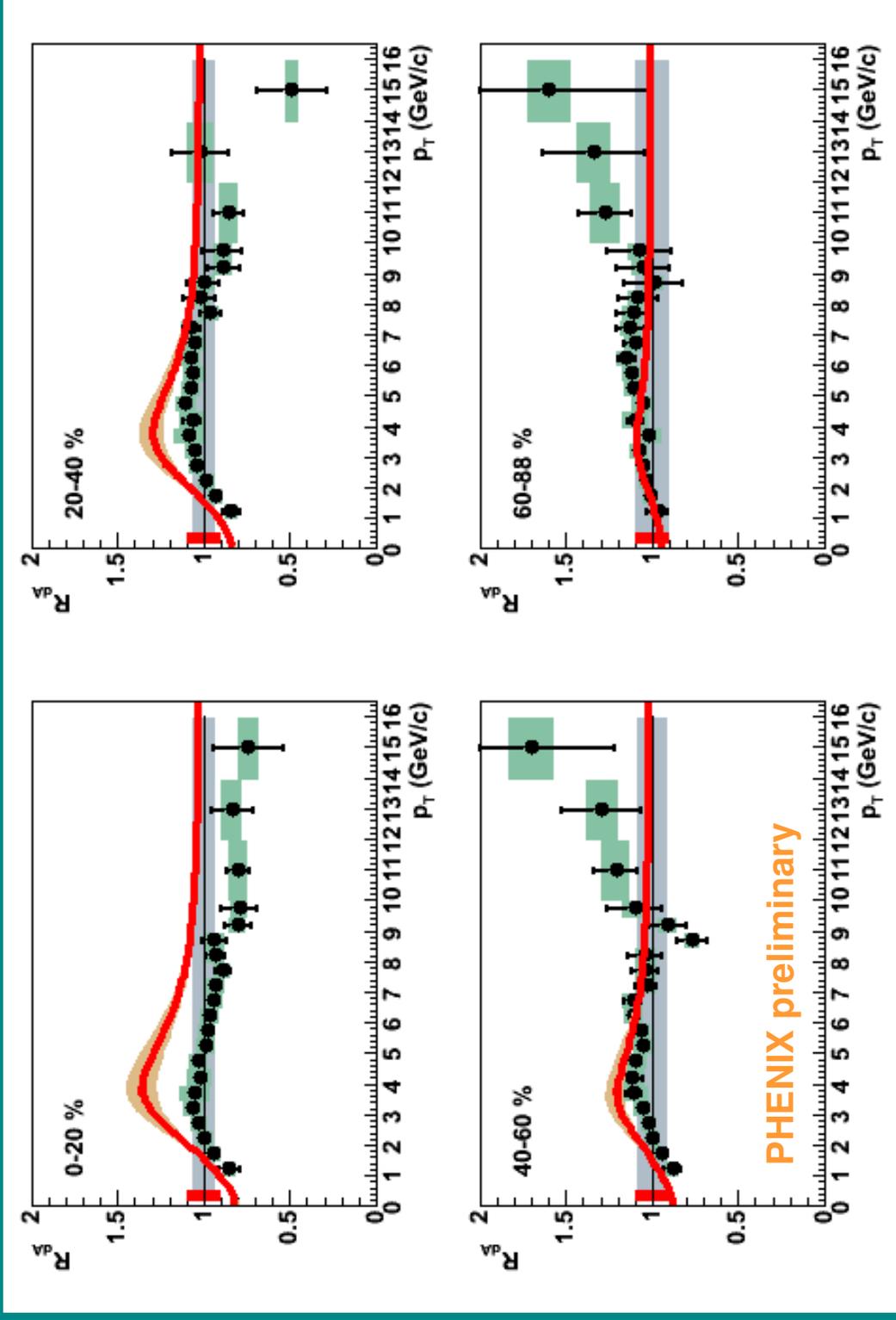
initial state effects

$\pi^0 R_{dA}$ – centrality dependence



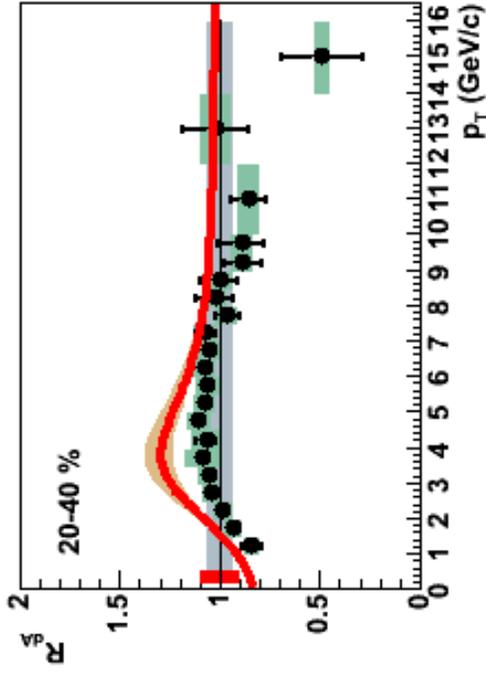
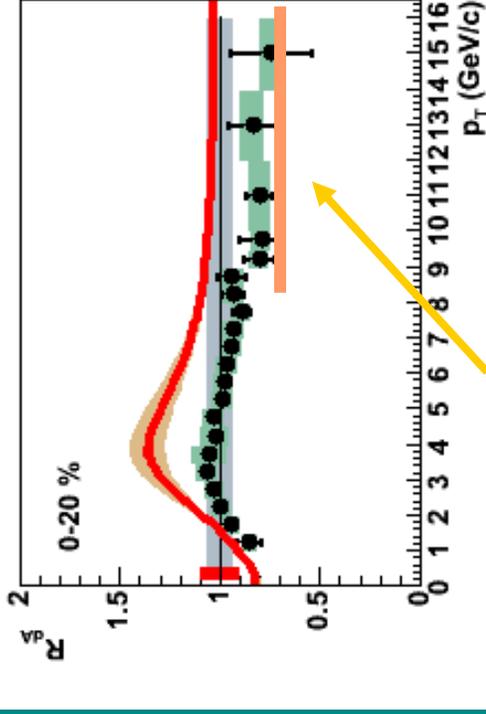
$\pi^0 R_{dA}$ – centrality dependence

$\langle k_T \rangle =$
 0.52 GeV^2

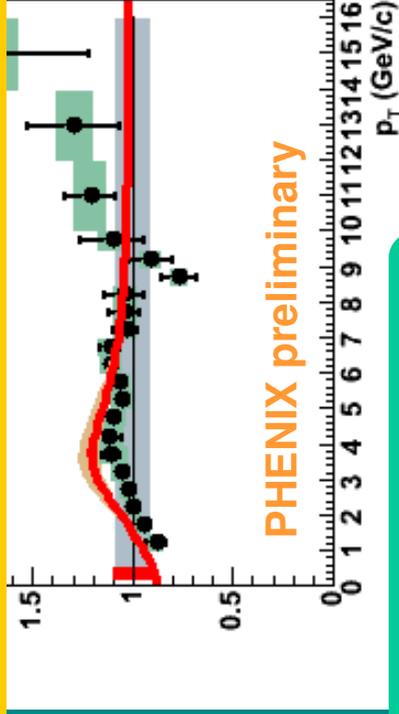


Qualitative agreement with model by Accardi and Gyulassy.
Partonic Glauber-Eikonal approach: sequential multiple partonic collisions.
nucl-th/0308029 v2

$\pi^0 R_{dA}$ – centrality dependence



Prediction for gluon saturation

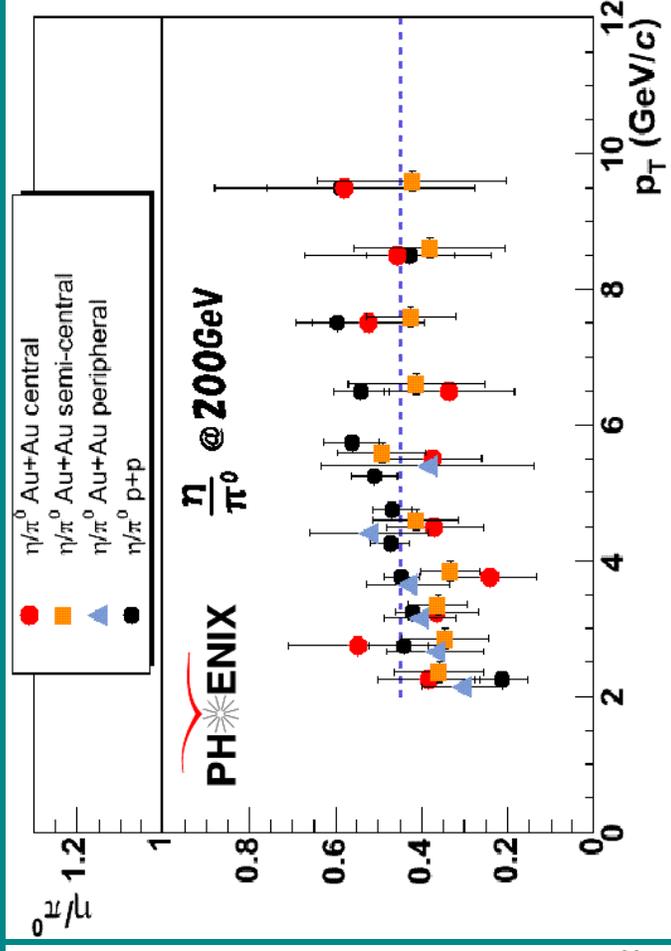
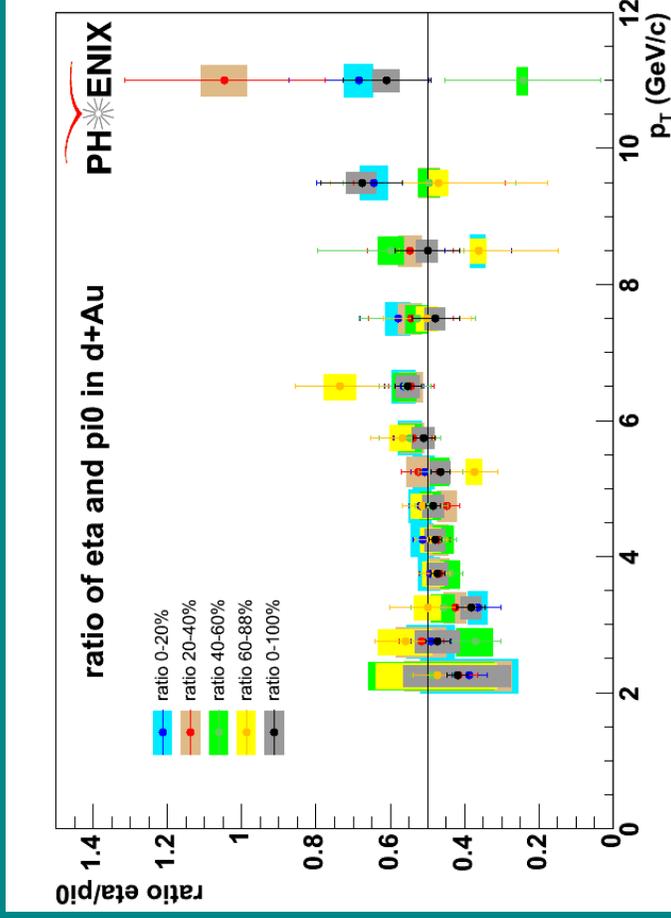


PHENIX preliminary

Kharzeev, Levin, McLerran,
 hep-ph/0210332

$(N_{\text{part, Au}})^{1/2}$ scaling
 $R_{AA} \approx 0.7$ in central d+Au

η/π^0 ratio



d+Au

p+p

Au+Au

$\eta/\pi^0 \sim 0.4 - 0.5$. in all systems and for all centralities

$\sqrt{s_{NN}} = 200$ GeV

Conclusions

- 4 main discoveries in single particle spectra at high p_T in Run 1-3
- Wealth of new data in Run 4 and 5
- Allows systematic study of
 - Collision energy
 - Geometry
 - Particle species
- **Particle Suppression**
 - π^0 flat up to high p_T
 - η similar to π^0
 - Similar in Cu+Cu for same N_{part}
 - π^0 production at 62.4 GeV consistent with parton energy loss model
- **Baryon anomaly**
 - Slight energy dependence of p/π ratios 62.4 - 200 GeV
 - N_{part} scaling of particle ratios and R_{AA}
- **Initial state effects**
 - Small centrality dependence of π^0 production in dAu
 - Initial-state effects small
 - Very similar for η production

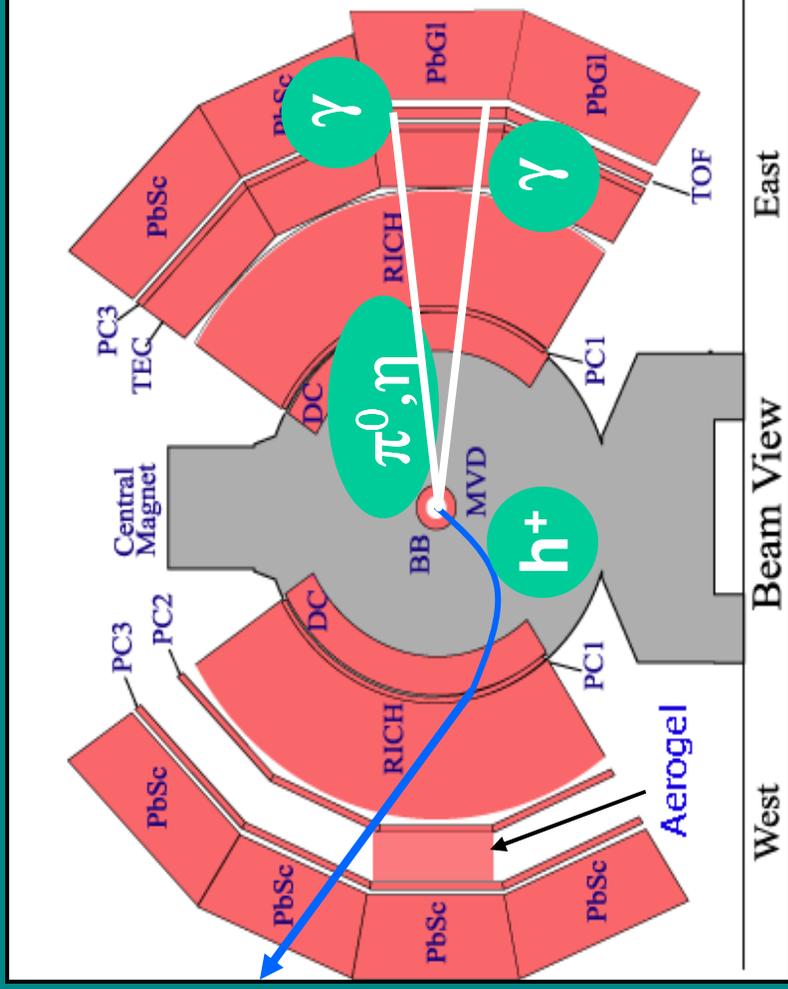




backup

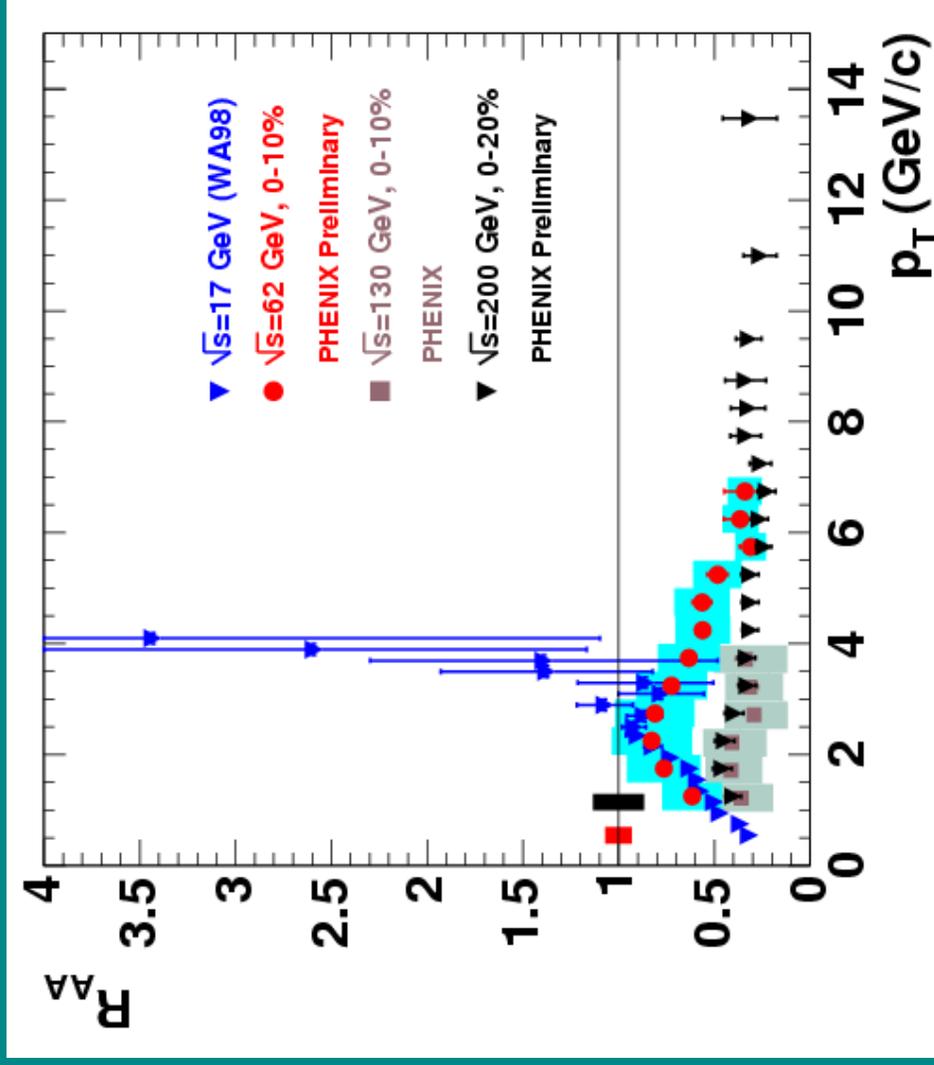
PHENIX-Setup

- Detectors in the central spectrometer arms
 - π^0, η via $\pi^0, \eta \rightarrow \gamma\gamma$:
 - Lead-scintillator calorimeter
 - Lead-glass calorimeter
 - - charged particles
 - Drift chamber
 - Pad Chamber
 - Aerogel ← **new**
- Centrality, vertex
 - Beam-Beam Counter (BBC) $3.0 < |\eta| < 3.9$
 - Zero-Degree Calorimeter



(pseudorapidity $|\eta| < 0.35$)

$\pi^0 R_{AA}$, Central Events, Different \sqrt{s}



- Suppression at 17 GeV and 62.4 GeV similar at medium p_T
- 62.4 GeV expected lower
- Better reference needed!

WA98, EPJ C 23, 225 (2002)

[new reference compiled by D.d'Enterria
nucl-ex/0403055]

PHENIX, PRL 88 022301 (2002)